U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-268 261

Belton Reservoir, Bell and Coryell Counties, Texas

National Eutrophication Survey, Corvallis, Oreg

Prepared for

Corvallis Environmental Research Lab, Oreg

Feb 77

PB 268 281

Report
on
BELTON RESERVOIR
BELL and CORYELL COUNTIES
TEXAS
EPA REGION VI
Working Paper No. 633

With the cooperation of the
Texas Water Quality Board
and the
Texas National Guard
February, 1977

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Report on Belton Reservoir, Bell and Coryell Counties, Texas		5. REPORT DATE Prepared February 1977
7. AUTHOR(S) Anonymous (National Eutrophication Survey Staff)		8. PERFORMING ORGANIZATION REPORT NO. Working Paper # 633
9. PERFORMING ORGANIZATION NAME AND ADDRESS National Eutrophication Survey U.S. Environmental Protection Agency 200 S. W. 35th St. Corvallis, Oregon 97330		10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Office of Research and Development U.S. Environmental Protection Agency 401 M Street, S. W. Washington, DC 20460		13. TYPE OF REPORT AND PERIOD COVERED Final - 1974 14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

Prepared in cooperation with the U.S. Environmental Protection Agency, National Environmental Research Center, Las Vegas, Nevada 89114

16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
eutrophication lakes nutrients phosphorus nitrogen loading		05B 06C
18. DISTRIBUTION STATEMENT Release unlimited	19. SECURITY CLASS (This Report) 20. SECURITY CLASS (This page)	21. NO. OF PAGES 22. PRICE

A04 - A01

CONTENTS

	Page
Foreward	ii
List of Texas Study Reservoirs	iv
Lake and Drainage Area Map	vi

Sections

I.	Conclusions	1
II.	Lake and Drainage Basin Characteristics	4
III.	Lake Water Quality Summary	5
IV.	Nutrient Loadings	11
V.	Literature Reviewed	17
VI.	Appendices	18

FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGEMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Texas Water Quality Board for professional involvement, to the Texas National Guard for conducting the tributary sampling phase of the Survey, and to those Texas wastewater treatment plant operators who voluntarily provided effluent samples.

Hugh C. Yantis, Jr., Executive Director of the Texas Water Quality Board, and John B. Latchford, Jr., Director, and the staff of the Field Operations Division provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

Major General Thomas Bishop, the Adjutant General of Texas, and Project Officer Colonel William L. Seals, who directed the volunteer efforts of the Texas National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

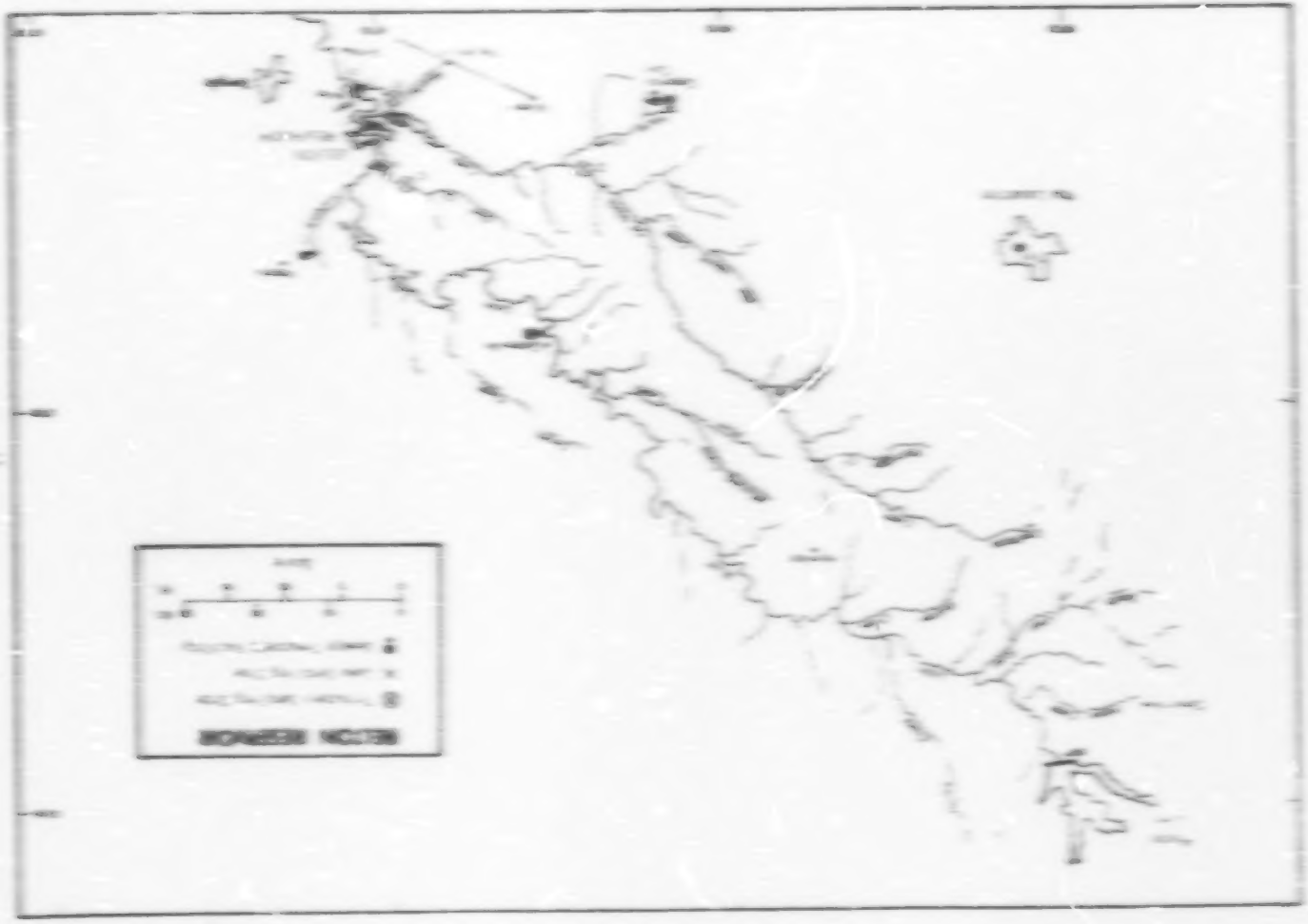
NATIONAL EUTROPHICATION SURVEY

STUDY RESERVOIRS

State of Texas

NAME	COUNTY
Amistad	Val Verde
Bastrop	Bastrop
Belton	Bell, Coryell
Braunig	Bexar
Brownwood	Brown
Buchanan	Burnet, Llano
Caddo	Harrison, Marion, TX; Caddo Parish, LA
Calaveras	Bexar
Canyon	Comal
Colorado City	Mitchell
Corpus Christi	Jim Wells, Live Oak, San Patricio
Diversion	Archer, Baylor
Eagle Mountain	Tarrant, Wise
Fort Phantom Hill	Jones
Houston	Harris
Kemp	Baylor
Lake O'The Pines	Camp, Marion, Morris, Upshur
Lavon	Collin
Lewisville (Garza-Little Elm)	Denton
Livingston	Polk, San Jacinto, Trinity, Walker

Lyndon B. Johnson	Burnet, Llano
Medina	Bandera, Medina
Meredith	Hutchinson, Moore, Potter
O. C. Fisher (San Angelo)	Tom Green
Palestine	Anderson, Cherokee, Henderson, Smith
Possum Kingdom	Palo Pinto, Stephens, Young
Sam Rayburn	Angelina, Jasper Nacogdoches, Sabine, San Augustine
Somerville	Burleson, Lee, Washington
T. V. Spence	Coke
Stamford	Haskell
Stillhouse Hollow	Bell
Tawakoni	Hunt, Rains, Van Zandt
Texoma	Cooke, Grayson TX; Bryan, Johnston, Love, Marshall, OK
Travis	Burnet, Travis
Trinidad	Henderson
Twin Buttes	Tom Green
White River	Crosby
Whitney	Bosque, Hill
Wright Patman (Texarkana)	Bowie, Cass



BELTON RESERVOIR

STORET NO. 4803

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Belton Reservoir is meso-eutrophic; i.e., moderately well supplied with nutrients and productive. Whether nutrient enrichment is beneficial or deleterious depends on the actual or potential effect on the uses of the reservoir. In this regard, no nuisance conditions are known to personnel of the Texas Water Quality Board and there is little or no impairment of the designated beneficial uses of Belton Reservoir.

Belton Reservoir ranked eleventh in overall trophic quality when the 39 Texas reservoirs sampled in 1974 were compared using a combination of six parameters*. Three of the reservoirs had less median total phosphorus, two had less and five had the same median dissolved orthophosphorus, 28 had less median inorganic nitrogen, 12 had less mean chlorophyll a, and one had greater mean Secchi disc transparency. Marked depression of hypolimnetic dissolved oxygen occurred at all four sampling stations in May and August.

Survey limnologists did not observe macrophytes or algal blooms during any sampling time, but chlorophyll a concentrations were somewhat high at station 4 in May, August, and November and at station 1 in August (see page 9).

* See Appendix A.

B. Rate-Limiting Nutrient:

The algal assay results indicate phosphorus was the limiting nutrient when the assay samples were collected in May and November. The reservoir data indicate phosphorus limitation at all sampling times.

C. Nutrient Controllability:

1. Point sources--The phosphorus contribution of known point sources amounted to 12.2% of the total load to Belton Reservoir during the sampling year. Most of the point-source load was contributed by Copperas Cove (8.7%) and Gatesville (2.5%).

The present phosphorus loading of 3.95 $g/m^2/yr$ is over seven times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 16), and all phosphorus inputs to Belton Reservoir should be minimized to the greatest practicable degree to slow the aging of the reservoir.

2. Non-point sources--Non-point sources contributed 87.8% of the total phosphorus load to the reservoir. The Leon River contributed 16.8% of the total; Cowhouse Creek, 65.3%; and the ungaged tributaries contributed an estimated 5.3%.

The phosphorus export rates of the Leon River and Cowhouse Creek were 5 and 71 $kg/km^2/yr$, respectively (see page 15). The export rate of the Leon River compares quite well to rates of tributaries of other Texas reservoirs, but the export rate of Cowhouse Creek was considerably higher. This higher rate may be due to unidentified point sources rather than to non-point source inputs. There are a

number of small communities served by septic tanks that may be impacting Cowhouse Creek, but more extensive sampling would have to be done to establish the significance of these possible sources.

II. RESERVOIR AND DRAINAGE BASIN CHARACTERISTICS[†]

A. Morphometry[††]:

1. Surface area: 50.27 kilometers^2.
2. Mean depth: 10.8 meters.
3. Maximum depth: ~25.6 meters.
4. Volume: 545.188 x 10^6 m^3.
5. Mean hydraulic retention time: 1.6 years (based on 1972-1976 mean outflow).

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Leon River	6,720.8	10.11
Cowhouse Creek	1,815.6	5.41
Minor tributaries & immediate drainage -	636.6	2.80
Totals	9,181.0	18.32

2. Outlet -

City of Killeen aqueduct	0.0	0.70**
Leon River	9,230.8	16.41
Totals	9,230.8***	17.11***

C. Precipitation****:

1. Year of sampling: 89.1 centimeters.
2. Mean annual: 86.4 centimeters.

† Table of metric conversions--Appendix B.
†† At conservation pool level; Barrows, 1977.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** White, 1976.
*** Includes area of reservoir; lesser outflow due to evaporation.
**** See Working Paper No. 175.

III. RESERVOIR WATER QUALITY SUMMARY

Hatton Reservoir was sampled four times in 1974 by means of a pontoon-equipped huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at four stations on the reservoir (see map, page v). During each visit, a single depth-integrated (4.6 m to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the March and November visits, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 25.3 meters at station 1, 25.6 meters at station 2, 25.3 meters at station 3, and 11.0 meters at station 4.

The sampling results are presented in full in Appendix D and are summarized in the following table (the August nutrient samples were not preserved properly and were not analyzed).

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
03/13/74	1. Chroomonas sp.	539
	2. Cryptomonas sp.	136
	3. Scenedesmus sp.	67
	4. Pennate diatoms	34
	5. Aphanocystis sp.	34
	Total	809
05/20/74	1. Oocystis sp.	2,057
	2. Mycrocystis sp.	851
	3. Coelastrum sp.	562
	4. Dinobryon sp.	452
	5. Chroomonas sp.	401
	Other genera	953
	Total	5,268
08/14/74	1. Raphidiopsis sp.	885
	2. Anabaenopsis sp.	442
	3. Oscillatoria sp.	221
	4. Coelosphaerium sp.	184
	5. Pennate diatoms	148
	Other genera	553
	Total	2,433
11/01/74	1. Chroomonas sp.	499
	2. Merismopedia sp.	461
	3. Anabaenopsis sp.	384
	4. Dactylococcopsis sp.	269
	5. Raphidiopsis sp.	192
	Other genera	577
	Total	2,382

2. Chlorophyll A -

Sampling Date	Station Number	Chlorophyll A (ug/l)
03/15/74	1	1.1
	2	1.2
	3	1.4
	4	3.2
05/20/74	1	3.2
	2	7.4
	3	6.3
	4	24.0
08/14/74	1	35.0
	2	5.9
	3	4.8
	4	18.6
11/01/74	1	1.4
	2	3.2
	3	3.8
	4	12.6

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

a. March sample -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.005	0.223	0.1
0.050 P	0.055	0.223	0.6
0.050 P + 1.0 N	0.055	1.223	5.4
1.0 N	0.005	1.223	0.1

b. November sample -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.005	0.132	0.3
0.050 P	0.055	0.132	4.1
0.050 P + 1.0 N	0.055	1.132	16.6
1.0 N	0.005	1.132	0.2

2. Discussion -

The control yields of the assay alga, Selenastrum capricornutum, indicate that the potential primary productivity of Belton Reservoir was low at the times the assay samples were collected. Both assays yielded similar results. There was a significant growth response when phosphorus was added alone, but no change in yield occurred with the addition of only nitrogen. These results indicate that phosphorus was limiting at the times of sample collection (03/13/74 and 11/01/74).

The reservoir data substantiate the assay findings. The mean inorganic nitrogen to orthophosphorus ratios were 25 to 1 in March, 32 to 1 in May, and 16 to 1 in November.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Texas National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page vi), except for the months of April and May when two samples were collected. Sampling was begun in September, 1974, and was completed in August, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Texas District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were calculated using mean annual concentrations and mean annual flows. Nutrient loads shown are those measured minus point-source loads, if any.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the mean concentrations in the Leon River at station A-2 and the mean annual ZZ flow.

The operators of the Copperas Cove and Moody wastewater treatment plants provided monthly effluent samples and corresponding flow data. The communities of Gatesville and Morgan's Point did not participate; nutrient loads were estimated at 1.134 kg P and 3.401 kg N/capita/year, and flows were estimated at 0.3785 m^3/capita/day.

A. Waste Sources:

1. Known municipal[1] -

Name	Pop. Served	Treatment	Mean Flow (m^3/d)	Receiving Water
Copperas Cove -				
SE	10,000	stab. pond	3,064.0	House Creek
NW	7,500	stab. pond	1,900.9	House Creek
Moody	1,286	Imhoff tank	447.1	Stampede Creek
Gatesville*	4,400	tr. filter	1,665.1	Leon River
Morgan's Point**	160	?	60.6	Belton Reservoir

2. Known industrial - None

[1] Treatment plant questionnaires.
* Anonymous, 1971.
** Wyatt, 1976.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Leon River	33,270	16.8
Cowhouse Creek	129,665	65.3
b. Minor tributaries & immediate drainage (non-point load) -	10,595	5.3
c. Known municipal STP's -		
Copperas Cove		
NE	10,525	5.3
NW	6,795	3.4
Moody	1,720	0.9
Gatesville	4,990	2.5
Morgan's Point	180	0.1
d. Septic tanks* -	50	<0.1
e. Known industrial - None	-	-
f. Direct precipitation** -	870	0.4
Total	198,660	100.0

2. Outputs -

Lake outlet -	Killeen aqueduct	375
	Leon River	17,080
Total		17,455

3. Net annual P accumulation - 181,205 kg.

* Estimate based on 120 lakeshore dwellings, nine parks, and one campground; see Working Paper No. 175.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/ yr	% of total
a. Tributaries (non-point load) -		
Leon River	470,930	48.4
Cowhouse Creek	235,100	24.6
b. Minor tributaries & immediate drainage (non-point load) -	134,570	14.1
c. Known municipal STP's -		
Copperas Cove		
NE	21,565	2.3
NW	15,115	1.6
Moody	5,380	0.6
Gatesville	14,965	1.6
Morgan's Point	545	<0.1
d. Septic tanks* -	1,945	0.2
e. Known industrial - None	-	-
f. Direct precipitation** -	53,740	5.6
Total	953,855	100.0

2. Outputs -

Lake outlet -	Killeen aqueduct	13,620
	Leon River	467,310
Total		480,930

3. Net annual N accumulation - 472,925 kg.

* Estimate based on 120 lakeshore dwellings, nine parks, and one campground, see Working Paper No. 175.
** See Working Paper No. 175.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Leon River	5	70
Cowhouse Creek	71	179

E. Mean Nutrient Concentrations in Ungaged Stream:

Tributary	Mean Total P Conc. (mg/l)	Mean Total N Conc. (mg/l)
Owl Creek	0.013	0.991

f. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m²/yr	3.95	3.60	19.0	9.4

Vollenweider phosphorus loadings (g/m²/yr) based on mean depth and mean hydraulic retention time of Belton Reservoir:

"Dangerous" (eutrophic loading)	0.52
"Permissible" (oligotrophic loading)	0.26

V. LITERATURE REVIEWED

Anonymous, 1971. Inventory of municipal waste facilities. EPA Publ. OWP-1, vol. 6, Wash., DC.

Barrows, David, 1977. Personal communication (reservoir morphometry and hydraulic retention time). Canyon Proj. Off., Fort Worth Distr., Corps of Engrs., New Braunfels, TX.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

White, Carl, 1976. Personal communication (municipal water withdrawal from Belton Reservoir). Killeen.

Wyatt, Linda B., 1976. Personal communication (point sources impacting Belton Reservoir). TX Water Qual. Bd., Austin.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

[illegible]

LAKE CODE	LAKE NAME	[illegible] TOTAL *	[illegible] [illegible] %	[illegible] [illegible] SEC	[illegible] [illegible]	[illegible] [illegible]	[illegible] [illegible] [illegible] *
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible] OF LAKES WITH HIGHLY TALLIED NUMBER OF LAKES WITH [illegible] VALUES

LAKE CODE	LAKE NAME	[illegible] TOTAL #	[illegible] [illegible] %	MEAN SEC	[illegible] CYCLONES	[illegible]	[illegible] [illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] RESERVOIR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	LAKE [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	CADDO LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	CALAVERAS LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	CANYON RESERVOIR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	LAKE COLORADO CITY	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	CORPUS CHRISTI LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	FORT[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	EAGLE [illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	FT [illegible] [illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	GARZA LITTLE ELM RESERVO	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	HEMP LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	LAKE OF THE PINES	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	LAVON RESERVOIR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	LEWISVILLE LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	LYNDON B JOHNSON LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	MEDINA LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	LAKE [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	PALESTINE LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	POSSUM [illegible] RESERVOIR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	SAN ANGELO RESERVOIR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	SAN [illegible] RESERVOIR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	E V SPENCE RESERVOIR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible] PERCENT OF LAKES WITH HIGHER VALUES [illegible] PERCENT OF LAKES WITH HIGHER VALUES

LAKE CODE	LAKE NAME	[illegible] TOTAL P	[illegible] INORG N	[illegible] CHLA SEC	[illegible] COLOR	[illegible] PH	[illegible] CONDUCTIVITY	[illegible] TP
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKES RESERVOIR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] [illegible] RESERVOIR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO.
29	[illegible]	[illegible]	[illegible]
30	[illegible]	[illegible]	[illegible]
31	[illegible]	[illegible]	[illegible]
32	[illegible]	[illegible]	[illegible]
33	[illegible]	[illegible]	[illegible]
34	[illegible]	[illegible]	[illegible]
35	[illegible]	[illegible]	[illegible]
36	[illegible]	[illegible]	[illegible]
37	[illegible]	[illegible]	[illegible]
38	[illegible]	[illegible]	[illegible]
39	[illegible]	[illegible]	[illegible]

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

[illegible]

LAKE CODE [illegible] [illegible]

TOTAL [illegible] AREA OF LAKE(S) [illegible] [illegible]

SUB-DRAINAGE							NORMALIZED FLOWS(CMS)							
[illegible]	[illegible]	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	[illegible]
[illegible]	[illegible]	12.43	14.53	25.41	34.57	29.61	32.69	28.74	7.65	4.07	15.77	13.02	6.49	[illegible]
[illegible]	[illegible]	6.72	10.28	9.63	12.68	15.79	18.43	7.49	2.25	4.62	13.29	9.13	4.59	[illegible]
[illegible]	[illegible]	5.49	5.79	5.79	7.85	14.49	3.61	2.81	1.58	2.46	7.40	3.10	3.31	[illegible]
[illegible]	[illegible]	2.09	2.49	2.75	3.54	5.42	2.29	1.31	0.74	1.37	3.82	1.39	1.61	[illegible]

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = [illegible]
SUM OF SUB-DRAINAGE AREAS = [illegible]

TOTAL FLOW IN = [illegible]
TOTAL FLOW OUT = [illegible]

[illegible] MONTHLY FLOWS AND DAILY FLOWS(CMS)

[illegible]	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
[illegible]	9	74	6,387	7	25,465				
	10	74	31,735	12	46,888				
	11	74	25,362	15	42,142				
	12	74	42,676	16	42,759				
	1	75	73,624	16	88,119				
	2	75	61,731	24	74,654				
	3	75	41,858	11	29,834				
	4	75	42,681	6	5,858	24	77,588		
	5	75	13,594	4	8,8	10	1,671		
	6	75	48,859	22	94,268				
	7	75	11,347	23	8,398				
	8	75	2,678	17	8,413				
[illegible]	9	74	13,882	7	8,178				
	10	74	8,498	18	8,413				
	11	74	5,814	2	8,8				
	12	74	5,918	7	3,681				
	1	75	8,467	15	14,413				
	2	75	31,432	24	8,8	27	15,744		
	3	75	8,883						
	4	75	24,261	7	28,419	24	15,427		
	5	75	13,819	6	8,418	14	9,345		
	6	75	5,197						
	7	75	3,405	15	1,219				
	8	75	1,361	27	8,311				

APPENDIX D

PHYSICAL and CHEMICAL DATA

3/

[illegible]

[illegible]

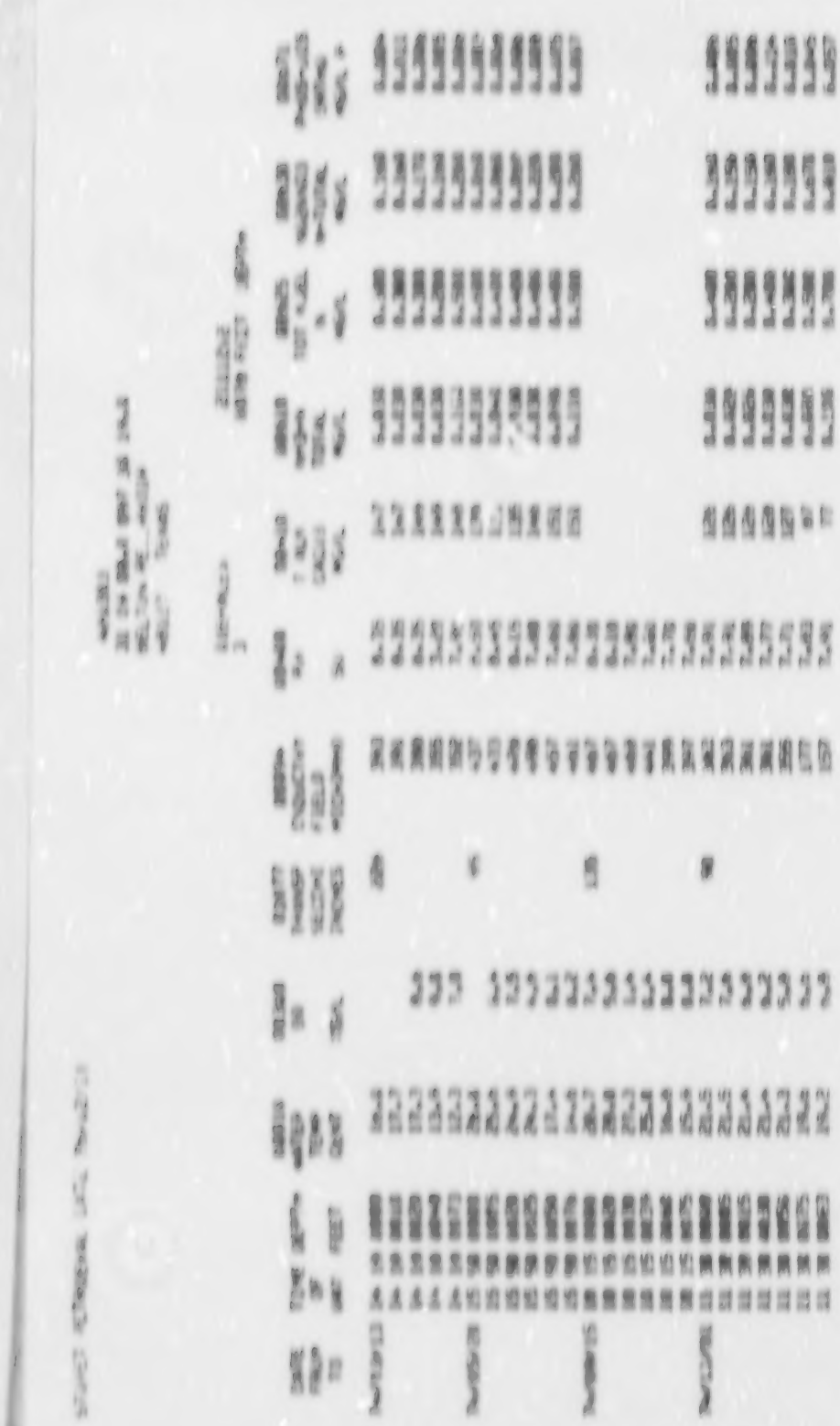
DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]			[illegible]	[illegible]
[illegible]	[illegible]	FEET	[illegible]	[illegible]	[illegible]
[illegible]	13 10	[illegible]	[illegible]	[illegible]	
	13 10	[illegible]	[illegible]		
	13 11	[illegible]	[illegible]		
	13 10	[illegible]	[illegible]		
	13 10	[illegible]	[illegible]		
	13 10	[illegible]	[illegible]		
[illegible]	24 10	[illegible]	[illegible]	[illegible]	
	24 10	[illegible]	[illegible]		
	24 10	[illegible]	[illegible]		
	24 10	[illegible]	[illegible]		
	24 10	[illegible]	[illegible]		
	24 10	[illegible]	[illegible]		
[illegible]	24 10	[illegible]		[illegible]	
	24 10	[illegible]			[illegible]
	24 10	[illegible]			[illegible]
[illegible]	24 10	[illegible]	[illegible]	[illegible]	
	24 10	[illegible]			[illegible]
	24 10	[illegible]	[illegible]		
	24 10	[illegible]			[illegible]
	24 10	[illegible]	[illegible]		
	24 10	[illegible]	[illegible]		
	24 10	[illegible]	[illegible]		
	24 10	[illegible]	[illegible]		

[illegible]

[illegible]

[illegible]

[illegible]			[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	13	45	[illegible]	[illegible]	1.3
	13	45	[illegible]	[illegible]	
	13	45	[illegible]	[illegible]	
	13	45	[illegible]	[illegible]	
	13	45	[illegible]	[illegible]	
[illegible]	15	28	[illegible]	[illegible]	7.4
	15	28	[illegible]	[illegible]	
	15	28	[illegible]	[illegible]	
	15	28	[illegible]	[illegible]	
	15	28	[illegible]	[illegible]	
[illegible]	15	45	[illegible]		5.7
[illegible]	15	15	[illegible]	[illegible]	3.3
	15	15	[illegible]		58.0
	15	15	[illegible]	[illegible]	
	15	15	[illegible]	[illegible]	1.0
	15	15	[illegible]	[illegible]	
	15	15	[illegible]	[illegible]	
	15	15	[illegible]	[illegible]	



[illegible]

[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]
FROM	OF			A	[illegible]
TO	DAY	FEET	[illegible]	[illegible]	[illegible]
[illegible]	04	10	[illegible]	[illegible]	
	04	10	[illegible]	[illegible]	
	04	10	[illegible]	[illegible]	
	04	10	[illegible]	[illegible]	
	04	10	[illegible]	[illegible]	
[illegible]	05	50	[illegible]	[illegible]	
	05	50	[illegible]	[illegible]	
	05	50	[illegible]	[illegible]	
	05	50	[illegible]	[illegible]	
	05	50	[illegible]	[illegible]	
	05	50	[illegible]	[illegible]	
[illegible]	10	25	[illegible]		
	10	35	[illegible]		
[illegible]	11	10	[illegible]	[illegible]	
	11	10	[illegible]		
	11	10	[illegible]	[illegible]	
	11	10	[illegible]	[illegible]	
	11	10	[illegible]	[illegible]	
	11	10	[illegible]	[illegible]	
	11	10	[illegible]	[illegible]	
	11	10	[illegible]	[illegible]	

APPENDIX E

TRIBUTARY AND WASTEWATER TREATMENT PLANT DATA

[illegible]

[illegible]

[illegible]	TIME	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TO	[illegible]	FEET	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	17	13	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	11	37	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	09	36	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	10	40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	11	45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	10	35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	10	33	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	12	35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	13	40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	17	38	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	10	42	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	10	35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

[illegible]

[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							

[illegible]

[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	FEET	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

* VALUE KNOWN TO BE
LESS THAN INDICATED

[illegible]